ACTUATING DEVICE FOR SELF COOLING PACKAGING

The invention relates to the field of self cooling packaging.

In particular, the invention relates to packaging device allowing cooling of its contents by use of a sorption cooling method. The principle of such a cooling method consists of evaporating a liquid under the effect of a vacuum sustained by adsorption of the vapours of said liquid.

The invention is applicable most particularly to the cooling of a beverage contained in a can or bottle type closed package. The object of the present invention is thus to allow the consumption of a beverage at an ideal temperature anywhere and at any time. However, the invention is also applicable to any other packaging containing products that need to be refrigerated right before use, such as cosmetic products, ice cream or other.

The implementation of the method of sorption cooling is known and has been the subject of much research in the prior art. Many devices have been proposed, associating a heat exchanger containing a refrigerant liquid to be evaporated with a cavity containing an adsorbent, in particular for applications to self-cooling beverage packages.

Patent Application WO 03/073019 relates to a self cooling packaging and an associated actuation device, an illustration of which is given figure 1.

This document discloses a packaging comprising a first cavity 10, which may contains a beverage; a second cavity 20 which forms a heat exchanger and which contains a refrigerating liquid and the vapour thereof; a third cavity 30 which contains means for the adsorption pumping of said vapour, such as desiccant. The second and third cavities are provided with a common wall 25 comprising a built-in connection means 40. Said connection means comprise a check valve 42 which can withstand pressure exerted on the side of the second cavity and which opens under the effect of a force exerted on the side of the third cavity.

This check valve 42 can therefore resist atmospheric pressure while maintaining vacuum inside the desiccant chamber 30 formed by the third cavity and can be easily actuated with minimum effort to the inside of the heat exchanger 20 formed by second cavity.

The check valve 42 described in this document can be actuated by a plunger hollow rod 45 transmitting a displacement of at least one portion of a wall 35 of the third cavity 30 (desiccant chamber) opposite the wall 25 including the connection means 40 with the check valve.

The check valve 42 comprises two stroke opening means. A first opening position is activated by the plunger rod 45 and defines a restraint path for the vapour of the

refrigerant liquid and a second opening position defines an enlarged path to enhance vapour flow of the refrigerant liquid. In the first opening position, an obturating member of the valve 42 is maintained in contact with the end of the rod 45 by the overpressure of the second cavity 20 compared with the third cavity 30, limiting therefore the vapour path to inside the hollow rod through a small lateral opening. In the second position, when the overpressure has decreased, the obturating member falls inside the second cavity (heat exchanger), releasing a bigger opening to inside the hollow rod.

A liquid/gas state separating device can be provided inside the second cavity forming the heat exchanger. A description of such liquid/gas separating device is given in Patent Application WO 03/041841. Such a liquid/gas state separating device is capable of separating the molecules of vapour of the refrigerant liquid from drops of said liquid carried along by the flow of vapour.

However, when the vapour flow is very important, in particular when initiating the cooling process, such liquid/gas separating device can be overloaded. Therefore, combining such separating device with two stroke opening means permits to limit the vapour flow at the beginning of the cooling process, when the pressure difference between the desiccant chamber and the heat exchanger is very high, while avoiding slowing the cooling process when the pressure difference has decreased with the heat exchanger temperature. The pressure in the heat exchanger cavity is equal to the saturation vapour pressure of the refrigerant liquid, such as water for instance.

However, this two stroke opening is not sufficient when considering the strong variation of vapour flow between the cooling process initiation and the further cooling process.

For instance, when initiating the cooling process with a heat exchanger being at about 30°C, the saturation vapour pressure inside the cavity forming the heat exchanger is about 40mbar (4000Pa). This pressure drops to less then 10mbar (1000Pa) when the heat exchanger temperature has dropped to less then 10°C (see graph of figure 8) by means of the sorption cooling process.

At the beginning of the cooling process, when the desiccant sorption capacity is very high, the vapour flow varies proportionally to the pressure P. This variation of the vapour flow is too large to efficiently adjust the two stroke opening plunger rod of the prior art. The arrangement of the prior art does not allow to avoid drops of liquid to be drawn towards the desiccant chamber by the violence of the boiling of the refrigerant liquid when actuating the connection means without limiting the evaporating speed of said refrigerant liquid, and therefore limiting the cooling speed of the heat exchanger.

Therefore, the invention provides enhanced connection means between the cavity forming the heat exchanger and the cavity forming the desiccant chamber. In place of

two stroke opening means, progressive opening means are provided for a check valve in a self cooling packaging device.

In particular, the invention concerns a self cooling packaging comprising:

- a cavity forming a heat exchanger and containing a refrigerant liquid and the vapour thereof;
- a cavity forming an adsorption chamber for pumping of said vapour;
- connection means provided in a common wall of said cavities, said connection means comprising a check valve;
- actuating means disposed on the side of the adsorption chamber cavity and adapted to open the check valve to an initial position;
- spring means, the check valve being adapted to progressively reach a fully open position under the action of said spring means.

According to a feature, the check valve is adapted to withstand pressure exerted on the side of the heat exchanger cavity and can be opened inside said heat exchanger cavity under the effect of a force exerted by said actuation means and said spring means.

According to a feature, the spring means are at rest when said connection means are in a closed position and are loaded by said actuating means in the initial opening position.

According to one embodiment, the spring means are part of the actuating means.

According to another embodiment, the spring means are part of the connexion means.

According to a feature, the actuating means comprise a plunger rod.

According to a feature, the spring means have a spring stroke comprised between 0.5 and 0.7 of the actuator plunger rod stroke.

According to one embodiment, the spring means comprise a helical spring.

According to another embodiment, the spring means comprise a tongue.

According to one embodiment, the check valve has a plate disk shape.

According to one embodiment, the connection means comprise a conical shape check valve and a conical shape valve seat formed in the common wall.

According to a feature, the conical shape has an angle with respect to the common wall comprised between 15° and 30°.

According to one embodiment, the connection means comprise a sealing member being compressed in a storage position in a direction perpendicular to the check valve opening direction.

According to a feature, the packaging further comprises a liquid/gas state separating device disposed in the heat exchanger cavity.

According to a feature, said liquid/gas state separating device defines a solid angle that includes the connection means.

The invention further concerns a method for cooling the content of a self cooling packaging, said packaging comprising:

- a cavity forming a heat exchanger and containing a refrigerant liquid and the vapour thereof;
- a cavity forming an adsorption chamber for pumping of said vapour;
- connection means provided in a common wall of said cavities, said connection means comprising a check valve;
- actuating means disposed on the side of the adsorption chamber cavity;
- spring means;

the method comprising the steps of:

- opening the check valve to an initial position under the action of said actuating means;
- pumping the vapour of the refrigerant liquid from the heat exchanger cavity to the adsorption chamber cavity;
- progressively opening the check valve to a larger opening with respect to the decrease of the pressure inside the heat exchanger cavity under the action of said spring means.

According to a feature, the method comprises the step of further dropping the check valve inside the heat exchanger cavity when the pressure therein has decreased to below a threshold value.

Other characteristics and advantages of the invention will appear on reading the following detailed description of the embodiments of the invention, given solely as an example, and with reference to the drawings which show:

- figure 1, a self cooling packaging according to the prior art ;
- figures 2a, 2b, 2c, a self cooling packaging according to the invention with the connection means respectively in a closed position, an actuated position and a progressive opening position;
- figure 3, a detailed view A of the connection means according to a first embodiment of the invention, in a closed position;
- figure 4, a detailed view of the connection means according to a second embodiment of the invention in a closed position;
- figure 5, a detailed view of the connection means according to an third embodiment of the invention in a closed position;
- figure 6, an embodiment of the present invention including a liquid/gas state separating device;

- figure 7, a detailed figure of the connection means according a fourth embodiment of the invention in an open position;
- figure 8, a diagram of the saturation vapour pressure depending on temperature in the heat exchanger;
- figure 9, a diagram comparing the valve flow rate according to the prior art and according to the invention.

The invention provides a self cooling packaging comprising a cavity forming a heat exchanger and containing a refrigerant liquid and the vapour thereof and a cavity forming an adsorption chamber for pumping of said vapour. The packaging also comprises connection means provided in a common wall of said heat exchanger and adsorption chamber cavities, said connection means comprising a check valve. Actuating means are also provided, disposed on the side of the adsorption chamber cavity and adapted to open the check valve to an initial position inside the heat exchanger cavity. The packaging further comprises spring means, the check valve being adapted to progressively reach a fully open position under the action of said spring means.

The invention makes it possible to realise a progressive opening of the check valve inside the heat exchanger cavity. The check valve conductance, providing a path for the vapour flow of the refrigerant liquid, progressively increases with the pressure decrease inside the heat exchanger cavity. Therefore, the vapour flow from the heat exchanger cavity towards the adsorption chamber cavity remains approximately constant during most of the cooling process. When the pressure decreases, making the vapour pumping speed decrease, the larger opening of the check valve provides a larger path for the vapour which compensate for the pressure decrease.

According to the invention and with reference to figures 2a to 2c, the packaging comprises a first cavity 10, which may contains a beverage or any other product to be refrigerated, a second cavity 20 which forms a heat exchanger and which contains a refrigerating liquid and the vapour thereof and a third cavity 30 which contains means for the adsorption pumping of said vapour, such as desiccant.

The second and third cavities are provided with a common wall 25 comprising a built-in connection means 40. Said connection means comprise a check valve 42.

The packaging further includes actuating means 45 adapted to actuate the connection means 40 to put the heat exchanger cavity 20 into communication with the adsorption chamber cavity 30 to permit the pumping of the vapour of the refrigerant liquid in order to refrigerate the heat exchanger and cool the content of the first cavity 10. The actuating means may comprise a hollow plunger rod 45 transmitting a

displacement of at least one portion of a wall 35 of the third cavity 30 (adsorption chamber) opposite the common wall 25 of said second and third cavities.

The packaging also includes spring means 43 adapted to cooperate with the connexion means 40 and the actuating means 45. The spring means 43 can be disposed in the actuating means, i.e. inside the plunger rod 45; or in the connexion means, i.e. attached to the check valve 42. The spring means 43 will be described in more detailed bellow with reference to preferred embodiments of the invention.

The check valve 42 of the connection means 40 is adapted to withstand pressure exerted from the side of the heat exchanger cavity 20 and can be opened inside said heat exchanger cavity 20 under the effect of a force exerted by said actuation means 45 and said spring 43 from the side of the adsorption chamber cavity 30.

The check valve 42 includes an obturating member closing an opening in the common wall 25 of the heat exchanger cavity 20 and the desiccant chamber cavity 30. This obturating member is preferably solid and can be made up by a metal disk.

The connexion means 40 also include a sealing 41 of the check valve 42 around the opening of the common wall 25. This sealing 41 may be a malleable joint disposed between the solid obturating member of the valve 42 and the common wall 25, such as vacuum grease or an elastomer. Alternatively, the sealing 41 may be a thin vacuum tight tearable sheet covering the obturating member of the valve 42, such as an aluminium sheet having 2/100mm thickness and being glued on the common wall 25. This sealing is not stressed by the high pressure from the side of the heat exchanger cavity 20 because of the check valve 42 design and offers only a very light resistance to the pressure exerted by the plunger rod 45 from the side of the desiccant chamber cavity 30.

Therefore, the check valve 42 of the connexion means can be easily opened only in one direction, towards the heat exchanger cavity 20.

The operation of the self cooling packaging device according to the invention is as follow. The packaging is preferably actuated upside down, that is to say with the adsorption chamber cavity 30 disposed above the heat exchanger cavity 20.

In non operated conditions, the connection means are closed (figure 2a).

Figure 3 is a detailed view A of the connection means according to a first embodiment in a closed position. The check valve 42 closes the opening of the common wall 25 between the heat exchanger cavity 20 and the adsorption chamber cavity 30 in vacuum tight conditions with the sealing 41. The check valve 42 has a plate disk shape slightly larger then the opening of the common wall 25.

The actuator plunger rod 45 is not in direct contact with the valve 42 and is in contact with at least one portion of the bottom wall 35 of the packaging. The distance L_0 between the end of the rod 45 and the valve 42 is less than the actuator stroke L_1.The

spring 43 is at rest between a fixing point inside the rod 45 and the valve 42 and thus induces no effort on the valve 42. The spring 43 can be abutted against the valve 42 but without exerting any force on it while the packaging is in non operated conditions. The distance L_0 is chosen approximately equal to the spring stroke.

In actuated conditions, the connection means are opened to an initial position (figure 2b). The plunger rod is pushed 45 transmitting a displacement of at least one portion of the bottom wall 35 wall. The check valve 42 is pushed by the plunger rod 45 inside the heat exchanger cavity 20. This actuation has two continuous steps. Firstly, the plunger rod 45 is pushed towards the valve 42 over a given length L_0 until it comes in contact with the valve. The spring 43 is compressed by said rod 45 against the valve 42 on said given length L_0. Secondly, the plunger rod 45 tears the sealing and pushes the valve 42 inside the heat exchanger cavity 20.

A path is therefore opened for the vapour of the refrigerant liquid contained inside the heat exchanger cavity 20 to be pumped by the desiccant inside the adsorption chamber cavity 30. At that moment, in the first fractions of second that follows the actuation of the connection means, the pressure in the heat exchanger cavity 20 is much higher than the pressure in the desiccant cavity 30. The valve 42 is therefore maintained pressed against the end of the rod 45, keeping the spring 43 in compressed conditions by the vapour pressure towards the opening in the common wall 25 of the second and third cavities 20, 30.

The obturating member of the valve 42 clogs the end of the hollow plunger rod 45 and the vapour path therefore uses a small lateral opening of the rod. The vapour flow can be limited while the pressure difference between the second and third cavities 20, 30 is high, preventing therefore the projection of liquid drops inside the desiccant chamber 30.

In cooling conditions, the connection means are progressively fully opened (figure 2c). While the pumping goes on, the temperature in the heat exchanger cavity 20 drops and the pressure therein drops accordingly. The spring 43 can therefore extend progressively and pushes the valve 42 further inside the heat exchanger cavity 20 until it reaches its rest position again. The vapour path from the heat exchanger cavity 20 to the adsorption chamber cavity 30 progressively increases with respect to the pressure decrease in the heat exchanger 20.

The rate and the stroke of the spring 43 are chosen accordingly. For instance, the rate of the spring can be comprised between 10 and 20 g/mm and the spring stoke can be comprised between 1 and 3 mm. The spring stroke preferably depends on the actuator stroke. The plunger rod 45 is adapted to load the spring 43 over the distance L_0 and has a stroke L_1 long enough to open the check valve to the initial position. The

spring stroke can be comprised between 0.5 and 0.7 of the actuator stroke. The optimal ratio between L_0 and L_1 is 2/3.

The obturating member of the valve 42 unclogs the end of the plunger 45 while remaining on the direct vapour path. The flow of vapour can therefore be increased from the heat exchanger cavity 20 towards the desiccant cavity 30 while still limiting the projection of liquid drops inside the desiccant chamber 30.

As the packaging is preferably actuated upside down, drops of liquid can be limited by gravity. Moreover, when the pressure inside the heat exchanger 20 has decreased to below a threshold value because of the cooling down, the obturating member of the check valve 42 falls inside the heat exchanger cavity 20 providing a larger path for the vapour towards the adsorption chamber cavity 30. The weight of the obturating member of the check valve 42 is chosen accordingly.

Figure 4 shows another embodiment of the connection means of the packaging according to the invention having different spring means. All other features remain similar. In the figures previously described, the spring means comprise a helical spring fixed on the inside wall of the hollow rod 45 at some predefined distance from the check valve 42. In figure 4, the spring 43 comprise a tongue provided at the end of the rod 45. The tongue 43 can be integral with rod 45. In a rest position (figure 4), the tongue 43 is straightened towards the check valve 42. The end of the actuator plunger rod 45 is still distant from the check valve over a given distance L_0 less then the actuator stroke L_1. In actuated condition (equivalent to figure 2b) the tongue 43 is bent on the end of the rod by pressure of the obturating member of the valve 42 and progressively straightens back pushing away the obturating member of the valve while the pressure decreases (equivalent to figure 2c).

The embodiment described with reference to figure 4 is easier and cheaper to manufacture but requires more fastidious adjustments of the spring rate.

According to an alternative embodiment, the tongue 43 is provided integral with the check valve 42. In a rest position (figure 4), the tongue is straightened towards the plunger rod 45. The end of the actuator plunger rod 45 is still distant from the check valve over a given distance L_0 less then the actuator stroke L_1. In actuated condition (equivalent to figure 2b) the tongue is bent against the obturating member of the valve 42 by the rod 45. Then, the tongue 43 progressively straightens back pushing away the obturating member of the valve while the pressure decreases (equivalent to figure 2c).

Figure 5 shows another embodiment of the connection means of the packaging of the invention. The connexion means 40 comprise a valve seat 44 comprising a cylindrical portion adapted to accommodate an obturating member of the check valve

42 having a corresponding cylindrical portion on its periphery. This design allows using a sealing member 41 to be compressed between the walls of the cylindrical valve obturating member 42 and the cylindrical valve seat 44 respectively. Advantageously, such a sealing member can be an O-ring sealing 41.

The O-ring sealing being strongly compressed allows a better sealing efficiency between the heat exchanger cavity 20 and the adsorption chamber cavity 30 while in storage conditions, before actuation of the cooling process, while still requiring reduced effort for actuation, as the opening effort for the valve 42 is perpendicular to the O-ring compression effort. It is understood that the cylindrical portions of the valve obturating member 42 and the valve seat 44 may be replaced by slightly conical shapes or any other shape combination producing a compression of the sealing member 41 perpendicular to the check valve obturating member 42 displacement. The embodiment of figure 5 has been illustrated with the spring means of figure 3, but could just as well be realised with the spring means of figure 4.

Figure 6 shows an embodiment of the packaging according to the invention including a liquid/gas state separating device 50 provided in the heat exchanger cavity 20. Such a liquid/gas state separating device 50 is described in Patent application WO/03041841. Such a liquid/gas state separating device is capable of separating the molecules of vapour of the refrigerant liquid from drops of said liquid carried along by the flow of vapour. This liquid/gas state separating device 50 is a vapour deflector that induces at least one sudden change of direction to the vapour flow on its path to the opening of the common wall 25 towards the adsorption chamber cavity 30. This liquid/gas state separating device 50 is associated to the progressive opening of the connection means according to the invention to provide enhanced pumping conditions of the vapour of the refrigerant liquid.

Figure 7 shows another embodiment of the connection means of the packaging having a conical valve seat 44 and a valve obturating member 42 in an open position. Advantageously, this is associated with a check valve 42 having an obturating member of a conical shape instead of a plate disk shape previously illustrated. The inclination angle α is preferably the same for the valve seat 44 and the valve obturating member 42 and can be comprised between 15° and 30°.

The conical shapes of the valve seat 44 and valve obturating member 42 allow a good sealing provided by the inclined walls coated with adequate vacuum tight material, such as PTFE (Teflon™). This design however requires a longer actuator stroke L_1 compared with the design of figure 3 and 4 in order to pass the cone of the valve seat 44.

The embodiment of figure 7 can be combined likewise with any one of the embodiment of the spring means of figures 3 or 4.

N figure 7, the spring 43 has pushed the valve 42 inside the liquid/gas state separating device 50 to unclog the rod 45. The vapour path therefore goes from inside the heat exchanger cavity 20 to inside the liquid/gas state separating device 50 through the lateral openings 51 shown in figure 6, surrounds the valve obturating member 42 and flows between the inclined walls of the valve seat 44 and the valve obturating member 42 to inside the end and the lateral opening of the hollow rod 45.

When the vapour pressure inside the heat exchanger cavity 20 decreases under a threshold value, the valve obturating member 42 falls inside the liquid/gas state separating device 50.

Only the embodiment of figure 7 has been illustrated with a liquid/gas separating device. However, it is understood that any one of the embodiments described with reference to figures 3 to 5 may also include such a liquid/gas separating device.

Figure 9 illustrates the efficiency of the connection means of the packaging according to the invention.

When the pressure is high in the heat exchanger cavity (when initiating the cooling process), the flow rate towards the adsorption chamber cavity through the check valve having progressive opening means is smaller compared with the prior art, better preventing drops of the refrigerant liquid being pumped with the vapour.

During the cooling process, the flow rate decreases progressively, with a slight increase when the spring unclogs the rod. However, there is no step of sharp increase in the flow rate as in the prior art that may cause drops of liquid to flow with the vapour inside the desiccant chamber cavity.

The invention has therefore provided a self cooling package with progressive opening connection means allowing maintaining high pumping efficiency while better preventing drops of liquid being pumped together with the vapour.